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## METHOD AND APPARATUS FOR TRIMLESS SAMPLE CUP USED IN X-RAY SPECTROSCOPY

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### Field of the Invention

This invention relates to a sample cup for use in holding specimens for spectrochemical analysis, and more particularly to a sample cup comprised of a collar that pulls a thin film material taut over the open end of cell body, thereby obstructing one end of the cell body and creating the sample cup. The collar engages the thin film material in a manner that eliminates the need to trim the thin film material, thereby increasing the efficiency by which sample cups can be prepared.

### Background of the Invention

Spectroscopy is the science where a sample substance is analyzed by means of the spectra of light the sample absorbs or emits. Technological advancements in both wavelength-dispersive (WD-XRF) and energy-dispersive (ED-XRF) X-ray fluorescence instrumentation enable the spectroscopic analysis of virtually all types of sample materials. In this technology, sample cups or sample receptacles are employed to hold or contain liquid, solid and powdered specimens. Many conventional prior art sample cups consist of four components. The four components include a cell body with at least one open end; a thin film of material capable of covering the open end of the cell body; an annular collar used to pull the thin film of material taut over the open end of the cell body; and a snap-on ring used to secure the thin film of material in place. The thin film of material encloses a sample substance within the cell body and provides a sample surface plane which is exposed

to an excitation source, such as an X-ray tube, during the spectrochemical analysis. Such conventional prior art cups are exemplified by U.S. Patent No. Des. 238,693 entitled "CELL FOR X-RAY SPECTROSCOPY OR SIMILAR ARTICLE" issued on February 3, 1976 to Monte J. Solazzi; U.S. Patent No. 4,409,854 entitled "SAMPLE CUP WITH VENTING MEANS FOR USE IN X-RAY SPECTROSCOPY" issued on October 18, 1983 to Michael C. Solazzi; U.S. Patent No. 4,643,033 entitled "SAMPLE CUP FOR USE IN X-RAY SPECTROSCOPY" issued on February 17, 1987 to Monte J. Solazzi; U.S. Patent No. 4,665,759 entitled "SAMPLE CUP WITH A CANTILEVER BEAM VENTING MEANS" issued on May 19, 1987 to Monte J. Solazzi; and U.S. Patent No. 4,698,210 entitled "SAMPLE CUP APPARATUS FOR USE IN X-RAY SPECTROSCOPY EMPLOYING SELECTIVELY OPERATED VENTING MEANS" issued on October 6, 1987 to Michael C. Solazzi. All of the above patents are assigned to Chemplex Industries, the assignee herein.

During spectrochemical analysis it is essential for the surface of thin film material, which covers the opened top of the cell body, to remain planar in order to produce reliable data. The area of the thin film material that covers the top of the cell body, is known as the sample surface plane. During the spectrochemical analysis of certain specimens that exhibit a high abrogation in air, the sample cup retaining the specimen may be placed within a vacuum or inert gas environment. Under conditions where pressure equalization is not implemented, the thin film of material covering the sample will distend or bow outwardly due to the differential in pressures between the area within the sample cup and the environment surrounding the sample cup. This places portions of the thin film of material closer to the source of excitation. This variation in distance from the sample

plane to the source of excitation alters the intensity of the characteristic radiation of the specimen and also alters the intensity of radiation impinging upon the sample specimen from the excitation source. Consequently, the spectrochemical analysis may produce erroneous quantitative data. For applications in a gaseous environment where pressure is  
5 greater on the outside of the sample cup than within the sample cup, the thin film of material distends or is drawn into the hollow of the sample cup providing a concave sample surface. This effect increases the distance between the sample plane and the excitation source and results in erroneous analytical data.

In order to equalize pressure and eliminate distension of the sample surface  
10 plane, some sample cups are provided with a venting means. The venting means may be activated to provide pressure equalization between the inside and outside of the cup. Other sample cup designs include a main cell component with both ends opened. This double open-ended cup allows for attachment of the thin film sheet prior to the introduction of the sample. This design is useful for applications in an environment where continuous venting  
15 is desired from the moment of sample introduction.

In the prior art, when a sheet of the thin film material is positioned over the open end of a cell body by means of the annular collar, portions of the thin film of material extend beyond the collar along the outer walls of the cell body. This excess portion of the thin film of material has a tendency to flare away from the sides of the cell body and  
20 impairs the handling of the sample cup. As such, the excess thin film material must be trimmed from the sides of the cell body in order that the sample cup may be conveniently handled.

Furthermore, in the prior art, securing the thin film of material over the open end of the cell body is a two step process. First, the annular ring must be placed over the thin film of material so as to pull the thin film of material down along the sides of the cell body. Second, the snap-on ring must be applied to secure the thin film of material into place. The two step operation causes excessive manipulation of the thin film of material which often results in the ripping of the thin film of material as the thin film of material is repeatedly stressed against the cell body.

It is therefore an object of the present invention to provide an improved sample cup including a single piece snap-on collar designed to retain a thin film of material over the open end of a cell body, without having any portion of the thin film material extend beyond the snap-on collar. Such a design eliminates the need to trim extraneous thin film material from around the cell body. This simplifies sample cup preparation by reducing operational steps and labor required to assemble the sample cups.

It is also an object of the present invention to provide a sample cup which eliminates wrinkles in the thin film of material which covers the opened end of the cell body. The wrinkle-free thin film of material provides a consistently planar sample surface. Specially designed edges on the cell body prevent inadvertent tearing of the thin film sample support material during its attachment.

#### Summary of the Invention

The present invention is a sample receptacle for retaining a sample that is to be subjected to spectrochemical analysis. The present invention sample receptacle includes

a tubular body having at least one open end and a tapered exterior wall. A sheet of thin film material having peripheral edges is disposed across the open end of the tubular body. A generally annular collar, having an interior wall tapered at an angle supplemental to the taper of the interior wall, is disposed around the tubular body. As the annular collar is placed around the tubular body, the tapered exterior wall of the tubular body creates an interference fit with the tapered interior wall of the annular collar. The tapered surfaces of the tubular body and the annular collar engage the sheet of thin film material and pull the sheet of thin film material taut over the open end of the tubular body. The annular collar is sized to engage the entire length of the exterior wall of the tubular body. The portions of thin film material not covering the open end of the tubular body, including the peripheral edges of the thin film material, are compressed between the tapered exterior wall of the tubular body and the tapered inside wall of the annular collar. As such, the sample receptacle can be handled without having to trim extraneous thin film material from the sides of the tubular body.

#### 15 **Brief Description of the Drawings**

For a better understanding of the present invention, reference is made to the following description of exemplary embodiments thereof, considered in conjunction with the accompanying drawings, in which:

FIG. 1 is an exploded perspective view of a first exemplary embodiment of a sample cup according to the present invention;

FIG. 2 is a cross-sectional view of the exemplary sample cup embodiment of

FIG. 1 shown in a partially assembled configuration;

FIG. 3 is a cross-sectional view of the exemplary sample cup embodiment of Figs. 1 and 2 shown in an assembled configuration;

FIG. 4 is an exploded cross-sectional view of an alternate embodiment of the present invention sample cup; and

FIG. 5 is a cross-sectional view of the alternate embodiment of Fig. 4, shown in an assembled configuration.

### Detailed Description of the Drawings

Referring to FIG. 1, there is shown one preferred embodiment of a sample cup or receptacle 10 according to the present invention. The sample cup 10 consists of three members, that include a main cell body 12, a thin film material 16 and an annular collar 14 designed to secure the sheet of thin film material 16 over the cell body 12.

The cell body 12 includes a sample retaining region 21 and a reservoir region 23. The sample retaining region 21 of the cell body 12 is tubular in shape having an open end 22 and a closed end 20. The inner wall 25 of the sample retaining region 21 is generally cylindrical and extends in the vertical direction from the closed end 20 up to the open end 22. As such, the inner wall 25 defines a hollow 18, capable of retaining a sample specimen (not shown). The outside wall 26 of the sample retaining region 21 is tapered at an angle of inclination A. The outside wall 26 tapers toward the end 22 of the sample retaining region 21. As such, the outside wall 26 has a first diameter D1 at the open end 22 that is smaller than the second diameter D2 at the closed end 20 of the sample retaining

region 21. The edge 28 of the outside wall 26, proximate the open end 22, is rounded. Furthermore, a continuous semicircular groove 30 is disposed in the outside wall 26 proximate the edge 28.

5 The taper of the outside wall 26 ends at the interface of the sample retaining region 21 and the reservoir region 23. The reservoir region 23 is comprised of a cylindrical wall 32, having a vertical inside and outside surface, that surrounds and extends below the closed end 20 of the sample retaining region 21. A venting provision 38 may be disposed within the closed end 20. The venting provision 38 may be optionally ruptured, thereby allowing the hollow 18 of the sample retaining region 21 to communicate with the reservoir  
10 region 23. As such, any sample contained within the sample retaining region 21 can be vented to the reservoir region 23 as is currently practiced in many sample cups of the prior art.

A sheet of thin film material 16 is positioned over the open end 22 of the cell body 12. The thin film material 16 is flexible and transparent to the radiant energy used  
15 in the spectrochemical analysis. The possible compositions of such thin film materials 16 are well known in the art and need not be set forth herein at length.

An annular collar 14 is used to properly position the thin film material 16 across the open end 22 of the cell body 12. In the preferred embodiment, the annular collar 14 has a vertical height H that is at least as high as the sample retaining region 21 on the  
20 cell body 12. The annular collar 14 is generally tubular having first open end 45 and second open end 47. The annular collar 14 has an interior wall 42 which is tapered at an angle of inclination B that is supplementary to the angle of inclination A on the outside wall 26 of

the sample retaining region 21 of the cell body 12. The interior wall 42 tapers toward the second open end 47. As such, the first inner diameter D3 of the annular collar 14, proximate the first open end 45, is larger than the second inner diameter D4, proximate the second open end 47. The interior wall 42 has a rounded edge 29 proximate the second open end 47 that faces the interior of the annular collar 14. A continuous semicircular protrusion 44 extends inwardly from the interior wall 42 proximate the first end 45 of the annular collar 14. A lip extension 46 is disposed on the exterior of the annular collar 14. The lip extension 46 facilitates the handling and the alignment of the overall sample cup 10 when assembled and placed within spectroscopic instrumentation.

Referring to Fig. 2, it can be seen that as the annular collar 14 is advanced over the cell body 12, the thin film material 16 becomes pinched between the outside wall 26 of the cell body 12 and the interior wall 42 of the annular collar 14. As such, as soon as the second open end 47 of the annular collar 14 passes the open end 22 of the cell body 12, an interference fit occurs between the annular collar 14, thin film material 16 and cell body 12. Consequently, the thin film material 16 is immediately pulled taut across the open end 22 of cell body 12. As the annular collar 14 is further advanced along the cell body 12, the thin film material 16 is then pulled taut over the edge 28 of the outside wall 26 on the cell body 12. The rounded shape of the edge 28 prevents the thin film material 16 from being torn by the cell body 12. Similarly, as the annular collar 14 is advanced, the thin film material 16 is pulled across the edge 29 of the interior wall 42. The rounded shape of the edge 29 prevents the thin film material 16 from being torn by the annular collar 14.

As the annular collar 14 is advanced along the cell body 12, the interference



fit between the interior wall 42 of the annular collar 14, the thin film material 16 and the outside wall 26 of the cell body 12 increases due to the tapered shapes of both the interior wall 42 and the outside wall 26. As the forces of the interference fit increase, the tautness applied to the thin film material 16 increases, thereby eliminating any folds or wrinkles in the portion of the thin film material 16 covering the open end 22 of the cell body 12.

Referring to FIG. 3, it can be seen that the annular collar 14 completely engages the entire length of the sample retaining region 21 of the cell body 12 when the sample cup 10 is fully assembled. Assembly of the sample cup 10 is completed once the annular collar 14 is advanced far enough over the cell body 12 so that the semicircular protrusion 44 on the interior wall 42 of the annular collar 14 fits into the semicircular groove 30 on the outside wall 26 of the sample retaining region 21. Completion of assembly is indicated by a characteristic "snap" as the semicircular protrusion 44 coacts with the semicircular groove 30.

Once the sample cup 10 is assembled, the thin film material 16 is drawn tightly over the open end 22 of the cell body 12. The thin film material 16 creates a seal over the edge 28 of the cell body 12 which is impermeable to the sample contained therein. The interference fit between the tapered interior wall 42 of the annular collar 14 and the tapered outside wall 26 of the sample retaining region 21 of the cell body 12 occurs for the entire length of the annular collar 14. This prevents any loosening of the thin film material 16 that covers the opened end 22 of cell body 12. As such, the thin film material 16 will remain taut over the open end 22, creating a wrinkle-free sample surface plane for the spectrochemical analysis.

As mentioned, the interference fit between the annular collar 14 and the cell body 12 occurs over the entire length of the tapered surfaces. Any thin film material 16 not covering the open end 22 of the cell body 12 is compressed between the outside wall 26 of the sample retaining region 21 and the interior wall 42 of the annular collar 14. Provided an appropriate length of thin film material 16 is initially used, none of the thin film material 16 will extend beyond the length of the annular collar 14. Thus, the step of having to trim extraneous portions of thin film material 16 away from the exterior of the sample cup 10 is eliminated. Use of the sample cup 10 with the one-piece annular collar 14 greatly simplifies sample preparation since the number of operational steps are reduced.

Any time after the sample cup 10 is assembled, the sample substance may be subjected to spectrochemical analysis. This will normally require inverting the sample cup 10 so that the open end 22 of the main cell body 12 is facing downward. At that time, any substance contained within the sample cup 10 will come in contact with the portion of thin film material 16 covering the open end 22 of the sample retention region 21. The sample is then ready for analysis.

If venting is required during analysis of the sample contained within the sample cup 10, the venting provision 38 may be optionally ruptured with a blunt device for maintaining pressure equalization within the hollow 18 of the sample cup 10 and the X-ray optics environment. Venting of the sample cup 10 allows the thin film material 16 to maintain a planar sample surface over the open end 22 of the sample retaining region 21 by eliminating inward or outward distension under positive inert gas pressure and in an evacuated condition, respectively. The reservoir region 23 collects any temperature sensitive

fluid sample substances having tendencies to expand during analysis.

5 The main cell component 12 and the annular collar 14 are preferably fabricated from unrecycled natural polyethylene. This eliminates the potential possibility of introducing metallic contamination that may adversely affect the analysis of a sample substance. Polyethylene is one of a number of thermoplastic materials that can be utilized in this application because of its excellent mass attenuation properties encompassing the 1 to 12 Angstrom analyte wavelength range. In addition, polyethylene is resistant to chemical attack, temperature softening, and degradation from excitation energy sources, as well as exhibiting excellent tensile strength for adequate sample retention.

10 Referring to FIG. 4, a second preferred embodiment of a sample cup 50 according to the present invention is shown. The sample cup 50 consists of three members, and includes a main cell body 52, a thin film material 16 and annular collar 54 designed to secure the sheet of thin film material over the cell body 52. The cell body 52 includes a first open end 56 and a second open end 58. Other than the fact that both ends 56, 58 of the  
15 cell body are open, the sample cup 50 is identical to the sample cup 10 shown in FIGs. 1-3. Consequently, the annular collar 54 fits over the cell body 52 to secure the sheet of thin film material 16 in the manner previously described.

Referring to FIG. 5, the assembled sample cup 50 is shown with a sample substance 60 contained therein. The second open end 58 of the cell body 52 remains open  
20 even after the sample cup 50 is assembled. As such, the sample substance 60 located within the sample cup is always equalized to the pressure of the ambient environment. The sample substance 60 contacts the portion of thin film material 16 which covers the first open end

56 of the cell body 52. Since the pressure within the sample cup 50 is equalized by the second open end 58, the thin film material 16 which forms the sample surface, will remain consistently planar. The sample cup 50 is useful for applications analyzed in an air path or inert gas environment.

5           It will be understood that the present invention sample cups described herein are merely exemplary and that a person skilled in the art may make many variations and modifications to the described embodiment utilizing functionally equivalent components to those described. As such, variations and modifications, including differing physical geometrics, proportions and materials are intended to be included within the scope of the  
10 invention as defined in the appended claims.